The commercial production of Australian native finger lime *(Citrus australasica)* as an emerging industry in need of provenance, research and representation.

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Executive Summary

In the absence of representation and proprietorship, Australia stands to lose the provenance of some of its unique and extraordinary native foods and botanicals. Without protective measures, international companies have the potential to exploit and commercialise these foods, and to do so without acknowledging their origins. This loss of provenance not only threatens the cultural heritage tied to these foods but also the domestic economic opportunities they could generate. Strong provenance protections are essential to secure recognition and to sustain the cultural significance of Australia's native bushfoods.

As the peak industry body (PIB), Australian Native Food and Botanicals (ANFAB) aims to represent all interests in the rapidly growing Australian native food and botanical sector. Due to the diverse range of products at various stages of development, however, there is very little representation for each individual industry. Currently ANFAB attempts to represent the interests of 13 different native industries. With only limited support from the Australian Government these 13 native food industries lack any form of individual representation. In contrast, the Australian Macadamia nut industry has challenged this trend. It has done so through representation by the Australian Macadamia Society (AMS) which has enabled this industry to thrive. AMS has been successful through the provision of quality representation, acknowledgement of provenance, directed research and international leadership.

The finger lime, a native Australian citrus, is one such native food that is rapidly growing in popularity both in Australia and internationally. Until recently, the nascent finger lime industry has had only limited representation. Rather than individual representation, the question often posed has always been whether finger limes should sit under ANFAB or should they be included in the Australian Citrus PIB, Citrus Australia? There is an evidence-based argument that finger limes should, like many Australian native foods, form their own PIB. A finger lime PIB would have a twofold benefit; first, to ensure both the provenance and cultural recognition that is embodied in the goals of ANFAB are encompassed, and second, coordinating the in-depth species and industry-related research and marketing that Citrus Australia signifies.

This report explores finger limes and their increased popularity on the international stage. This increasing popularity raises the urgency for Australia to ensure it retains leadership of the finger lime industry and establishes and maintains the recognition of provenance for such a unique fruit. This report explores the rise of finger lime production internationally, including the realisation that the largest producer in the world is not in Australia where the fruit originates, but is, Prime Tropics, in Guatemala. Furthermore, this report covers the latest leading research by Australian Universities as well as the University of California, and it identifies the challenges ahead for greater industry leadership by Australia.

Detailed in the following pages, is a comprehensive investigation into the challenges and opportunities within a relatively new industry, and its need to ensure representation, provenance and leadership. Underscoring all of this is the need for continued research and development to ensure the viability and growth of finger lime production in Australia and beyond.

Keywords: Finger lime, provenance, bushfood, endemic, native foods

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Foreword

A passion for an increased understanding and knowledge of the unique Australian native citrus, *Citrus australasica*, commonly known as finger lime, inspired my Nuffield Scholarship journey. I started out in finger lime farming on my 30 hectare property on the Sunshine Coast with a small orchard of 350 trees, which I rapidly expanded to just under 2000 trees. I fell in love with the glass like pearls of citrus caviar and loved that these were Australian native fruit of such diverse colour and flavour. I produced three different varieties, Red Champagne, Chartreuse and Emerald. However, this venture into commercial finger lime farming identified a significant lack of knowledge available about the fruit and led me to initiate research into the optimal agronomic guidelines to produce a consistent quality of fruit and the need to ensure market expansion both nationally and internationally.

Once I began my research, I was surprised that many other countries were not just distributing Australian finger limes, but in fact, were growing and researching them on various levels as well. I realised very quickly that whilst finger lime was endemic to Australia, the largest growers were in Guatemala, and that the USA had significant research and breeding programs in place. I personally felt that as a native product, Australia should lead the way in finger lime production and research.

This also ignited the debate in many conversations regarding the proprietorship of this unique native fruit. The questions emerged as to whether the finger lime should be identified as an Australian product, or an Indigenous fruit giving sovereignty to Indigenous Australians?

Throughout my research in Australia, I noted that whilst some of the most informative research was being undertaken, and that many growers held some incredible knowledge and understanding, one of the key barriers to further development and collaboration was that no PIB representing finger limes had been established. It raised the question; how can we lead the world in our understanding of our native fruit when we have no PIB to coordinate and advocate?

The need to establish a consistent product and for consumer understanding of the varietal variation within the fruit was noted as shortfalls early in the research in both Australia and across the world. Once varietal variation is understood, market specifications are needed for each variety to ensure consumer expectations of appearance, size, longevity and taste are met.

The world looks to Australia for this knowledge, we need to embrace our fruit and lead.

The commercial production of Australian native finger lime (*Citrus australasica*) as an emerging industry in need of provenance, research and representation.

Table 1. Travel itinerary

Travel date	Location	Visits/contacts
Week 1-2 March 22-16, 2022	United Kingdom:	CSC Conference
Week 3	Italy:	Stefano Savini Alberto Tintori - Hesperidarium
Week 4	France:	Bachès Bénédicte et Michel - Baches Fingerlimes
Week 5	Spain:	Thierry and Régina - La Casa Del Limon de Carolina. Jose Huerta La Castoña - Gospa Citrus Fingerlimes Spain
Week 6 December 12th - 17th , 2022	Mexico:	Oaxaca and Yucatán lime production areas.
Week 7 December 18 – January 7th 2023	Guatemala:	Eddy Hernandez and Andres Quintanal – Prime Tropics
Week 8 January 8th – 14th 2023	California:	Jim SHANELY (deceased) – Shanely Farms University of California Lakeside
Week 9-11 April-May 2024	Texas, Germany and Ireland	Global Focus Program (GFP)
Various Dates	Australia	Australian First Nations Sovereign Foods & Botanicals Symposium - NT Byron Bay - Fingerlime Fresh - NSW EvokeAG - WA Oz Fingerlimes - VIC

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Acknowledgments

There are several people I would like to thank. First, Nuffield Australia and my investors, AgriFutures Australia, for this opportunity.

To Jodie and Nicola in particular, thanks for your efforts to keep us informed throughout everything, and always being willing to answer all the questions.

My family and friends for the encouragement, companionship on various trips, my actual work that worked around my travel and those that undertook caretaking of my farm whilst I travelled. Without everyone's support this would not have been possible.

On a more personal note, I'd like to extend a special thanks to my father, who has instilled in me an unwavering love and passion for Australian agriculture and a love for scientific research. Also, my husband, who has been my number one supporter and advocate.

Finally, to my CSC and GFP group, and the other scholars I've met along the way, you have been an invaluable network of support and assistance.

Figure 1. Contemporary Scholars Conference, United Kingdom, (source: author).

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Abbreviations

ACRA	Australian Cultivar Registration Authority
AMS	Australian Macadamia Society
ANFA	Australian Native Fingerlime Alliance
ANFAB	Australian Native Food and Botanicals
ANFIL	Australia Native Food Industry Limited
CSC	Contemporary Scholars Conference
GFP	Global Focus Program
GI	Geographical Indication
HIA	Hort Innovation Australia
ICIP	Indigenous Cultural and Intellectual Property
IP	Intellectual Property
MICOR	Manual of Importing Country Requirements
PBR	Plant Breeder's Rights
PDO	Protected Designation of Origin
PIB	Peak Industry Body
USA	United States of America

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Objectives

1. Understand the need to establish an industry body to represent all Australian stakeholders in the finger lime industry.
2. To understand agronomic practices to produce a consistent quality of fruit – key nutrient requirement etc across various climates and regions worldwide.
3. Varietal fruit specifications for consumers and supermarkets, size, shape, colour etc.
4. Identify opportunities for market expansion both nationally and internationally – to include supermarkets and increase exports, all while ensuring Australian quality and integrity.
5. Understand the role of provenance of finger limes as an Australian native product – addressing sovereignty, IP, Indigenous origins and recognition.

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Introduction

Finger limes (*Citrus australasica*) are native to the rainforests of Australia, specifically in the subtropical regions of Queensland and New South Wales. These small, elongated citrus fruits have been used by Indigenous Australians for thousands of years, both as a food source and for medicinal purposes. Traditionally, finger limes were foraged from the wild and played an important role in the diets of Aboriginal communities.

The fruit remained relatively unknown to the broader public until the late 20th century, when chefs and food enthusiasts began to recognise its unique qualities. Finger limes became highly sought after in gourmet circles for their "citrus caviar" texture—tiny, pearl-like juice vesicles that burst with flavour. This distinct characteristic, along with the fruit's bright colours and tangy taste, made it a popular ingredient in high-end cuisine.

In the 1990s, the potential for commercial cultivation of finger limes began to be explored. Australian farmers saw an opportunity to domesticate this native fruit, and it soon transitioned from being a wild crop to a commercially grown product. As interest in native foods grew, finger lime cultivation expanded, and by the early 2000s, they were being grown on small farms across Queensland and New South Wales.

From these small beginnings, the native finger lime industry has experienced significant growth over the past decade. A 2017 report (Coriolis, 2017) estimated the industry's gross value at $600,000, which increased to $3.1 million by 2020 (Laurie, 2020). The sector then included 20 major growers producing an estimated 78.3 tonnes and approximately 50 smaller growers contributing an additional 25 tonnes (AgriFutures Australia, 2021). Growth was projected at 8% from 2019 to 2025, driven by increased plantation areas.

The rapid expansion in recent years in finger lime production in Australia, driven by rising demand in both domestic and international markets, has unearthed that the industry faces challenges due to limited representation and coordination. Without a dedicated industry body or formal leadership, the sector lacks unified advocacy, making it difficult to address shared issues like market development, research, and best practices. Strong representation was noted to be essential to guide the finger lime industry forward and capitalise on its growth potential. The absence of organised efforts hinders broader dissemination of information, technological advancements, and industry growth. This highlights the objective to establish an industry body to represent all stakeholders in Australian finger limes.

Furthermore, there is limited knowledge of finger lime agronomy, posing a challenge for growers seeking to optimise production. Key aspects such as ideal soil conditions, pest management, irrigation techniques, and nutrient requirements remain under-researched, leading to inconsistent yields and quality. While experienced growers have valuable insights, there is a lack of comprehensive, publicly available information to support new or expanding producers. To ensure the industry's sustainable growth, more research is needed to address these agronomic gaps. Increased investment in research and extension services will improve cultivation practices, boost productivity, and strengthen the finger lime sector overall.

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Another objective that is needed in the finger lime industry is the establishment of standard finger lime varieties crucial to meet consumer and supermarket demands. Consistent specifications for size, shape, and colour will enhance marketability and ensure high-quality produce. Selecting the best varieties based on characteristics like uniform size (4-12 cm), vibrant skin colours (green, pink, red, or purple), and flavourful vesicles (green, pink, yellow, or red) is essential. Standardising these traits will improve consumer confidence, streamline supermarket distribution, and optimise pricing. Focused breeding programs and research will help identify superior varieties, ensuring the industry's growth and meeting the high expectations of both local and international markets.

Finally, the provenance of finger limes as an Australian native product plays a crucial role in addressing sovereignty, intellectual property (IP), and Indigenous recognition. As a native fruit, finger limes are deeply connected to Australia's Indigenous heritage, and acknowledging this origin respects the cultural significance and traditional knowledge of Indigenous communities. Ensuring proper IP protection safeguards the unique characteristics of finger limes, preventing unauthorised exploitation. Highlighting finger lime’s Australian origins reinforces authenticity and value in the global market. By addressing these factors, we promote ethical practices, respect cultural heritage, and enhance the credibility and market appeal of finger limes as a premium, Indigenous product.

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Chapter 1: Industry representation

Citrus was the second most produced fruit worldwide in 2021, accounting for 161.8 million tons produced on more than 10.2 million hectares. Only bananas and plantains combined exceeded this amount, reaching more than 170.3 million tons.

1.1 The Australian citrus industry

1.1.1 Australian citrus industry overview

Australia's citrus industry is one of the country's leading fresh produce exporters, with export volumes growing from 158,000 tonnes in 2014 to over 250,000 tonnes in 2020. Despite citrus' substantial domestic presence, Australian-grown citrus accounts for less than 3% of global citrus production and remains one of the highest-cost producers globally. The industry relies heavily on its strong reputation for quality and safety, enabling it to secure premium prices in lucrative export markets (Citrus Australia, 2024).

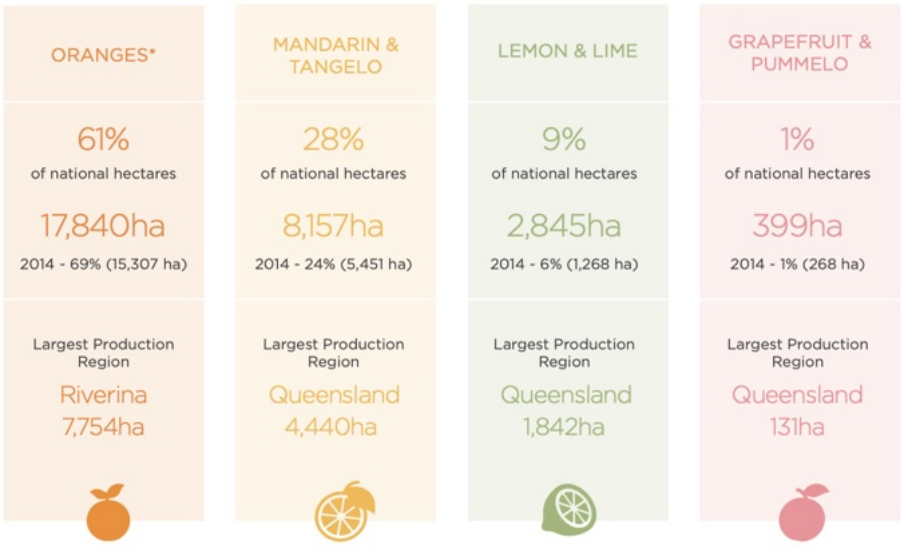

Figure 2. Citrus Australia 2023 Annual Report, (source: Citrus Australia, 2023).

1.1.2 Australian native citrus overview

Australia is home to six notable native citrus species, with the Finger lime (*Citrus australasica*) being the most commercially viable due to its high demand in gourmet food markets. Other species include the Desert lime (*Citrus glauca*), known for its drought tolerance and tangy flavour; the Round lime (*Citrus australis*), which offers a sweet, tart taste; the Russell River lime (*Citrus inodora*), valued for its large leaves and distinct aroma; the Mount White lime (*Citrus garrawayi*);

and the Kakadu lime (*Citrus gracilis*). While each species contributes to Australia's growing native food industry, finger limes lead in global appeal.

From modest beginnings, the native finger lime industry has seen remarkable growth over the past decade. According to a 2017 report (Coriolis, 2017), the industry's gross value was estimated at $600,000, rising to $3.1 million by 2020 (Laurie, 2020). At that time, the sector comprised 20 major growers producing around 78.3 tonnes, along with approximately 50 smaller growers adding another 25 tonnes (AgriFutures Australia, 2021). Growth is anticipated to continue at 8% annually from 2019 to 2025, driven by expanding plantation areas.

Figure 3. Locations where native finger lime is grown, (source: AgriFutures Australia, 2021).

These figures and the production areas are expected to rise as new varieties of finger limes are developed annually and as the market value of the Australian native or "Bushfood" industry grows. Currently valued at $80 million, the traditional food sector is anticipated to double by 2025 (Laurie, 2020; Nastasi, et al., 2024). Australian native citrus species, including finger limes, are recognised to be a significant domestic crop that will result in market expansion and development of primary industries and small enterprises (Hay, et al., 2022; Dissanayake, et al., 2023).

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1.2 International citrus industry

1.2.1 International citrus industry overview

The global citrus industry is a major segment of the agricultural market, with citrus fruits like oranges, lemons, limes, grapefruits, and mandarins being key commodities. The global production of citrus is estimated to reach 103.7 million tonnes for 2023/24 (Shahbandeh, 2024; Zang, 2024). China, Brazil, USA, India, Mexico, and Spain are the world's top citrus fruit-producing countries, representing close to two-thirds of global production (Lv, et al., 2015).

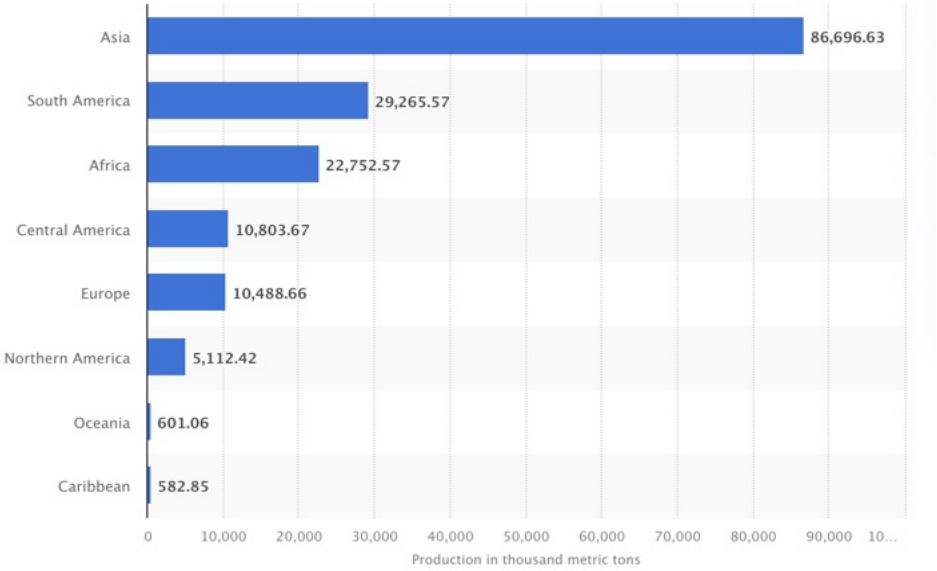

Figure 4. Global Citrus production by region, (source: Shahbandeh, 2024).

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Figure 5. Top 6 countries for citrus production, (source: Lv, et al., 2015).

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1.2.2 International finger lime industry overview

Finger lime production is predominantly centred in Australia and exact global figures are limited. Guatemala hosts one of the largest growers in the world with over 20 000 trees. California has over 12 000 trees and substantial research being conducted, whilst many other countries are also key producers, yet their production figures are unknown.

Table 2. International finger lime production outside of Australia, (source: AgriFutures Australia, 2022).

Country	Current production
Guatemala	20 000 trees in one plantation
California	Large growers, 5000 - 12000 trees across farms. New varieties. 20000 - 30000 trees across state.
Morocco	Large producers selling bulk product cheaply
Spain	Producers from 100 - 10000 trees.
France	Emerging industry
Italy	Emerging industry
Croatia	Emerging industry
Thailand	Emerging industry
Japan	Emerging industry

California finger limes

The United States Department of Agriculture first imported finger lime seeds and cuttings more than a century ago as a research subject, with the crop remaining at the research level into the twenty-first century. The University of California-Riverside (UC-Riverside) developed an interest in the crop and began rootstock trials and hybridisation research experiments with finger lime trees in 1965. As part of the UC-Riverside Citrus Variety Collection, UC scientists have released finger lime budwood for California nurseries to use in propagating trees. California is the only US state that grows finger lime on a commercial basis, at around 20-30 000 finger lime trees (Karp, 2009; Karp, 2022; Singh, et al., 2022).

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Figure 6. Lakeside Research Station, University of California and the Finger lime research team, (source: author).

Guatemala finger limes

Guatemala currently has the world's largest plantation of finger lime trees at 20 000 trees. At the peak of their season they harvest over 2000 kilograms per week and this is set to increase to 3000 kilograms per week as more trees come into full production. Communication with Edilson Hernandez (Prime Tropics manager) and Andres Quintanal (Prime Tropics owner), conveyed that they had the capacity to maintain a continuous supply of finger lime all year round, and they were predominantly supplying Central America, the Netherlands and other European Union countries. In a high manual labour operation, the cheap and accessible labour component of their finger lime production is a significant advantage. Adversely, it was also noted that there was a degree of uncertainty regarding varieties grown and accessed.

Figure 7. Prime Tropics Finger lime production team in Guatemala, (source: author).

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Figure 8. Prime Tropics Finger lime farm pictured from a helicopter, (source: author).

Italy finger limes

Finger lime production in Italy is very much in its infancy and is following a similar emergence as Australia in its early years. There are no major commercial farms as yet, however, nurseries are stocking for individuals and growing for future commercial production. However, in discussions with Stefano Savini, of Savini Vivai Nursery, it was noted that true to description varieties were difficult to ascertain.

Italy has one of the most extensive exotic Citrus collections, the Hesperidarium, with over 200 varieties of Citrus plants from all over the world. The Hesperidarium contains plants from the 15th century to more recently discovered varieties from the southern hemisphere, such as finger lime. Alberto Tintori (owner) has had increasing interest in the Australian finger lime and is seeking to obtain new varieties to add to the collection.

Figure 9. Stefano Savini at Savini Vivai Nursery, Italy, (source: author).

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Spain finger limes

Spain is renowned for its citrus production and is one of the top five producers of citrus in the world. In the 2023-2024 season, Spanish citrus exports totalled 2.34 million tonnes, despite a yield drop due to adverse weather conditions. Spain continues to be the world's leading trader of fresh citrus with a 25% share of world exports. Whilst citrus has been grown in Spain for hundreds of years, finger limes are very much an emerging industry, albeit one with a number of complexities.

One significant issue that is common to most countries starting to produce finger limes is the lack of understanding regarding the varieties. However, this is more concerning in Spain as there lies some confusion and subsequent incorrect naming of Frustrime (an F1 hybrid of *Citrus australasica* x lime) as Finger limes. The difference between the two is that Frustrime lacks the distinctive caviar-like pearls and instead has common citrus vesicles (Figure 10). Large commercial farms of over 3000 Frustrime are marketing their produce as finger lime, subsequently resulting in confusion in the market as to what is a finger lime.

Despite this, there are a number of commercial citrus growers, such as Gospa Citrus, who are expanding into finger lime production and sourcing their trees specifically as *Citrus australasica*, finger lime.

Figure 10. Finger limes Spain owner and image of Frustrime, an F1 hybrid of *Citrus australasica* x lime, (source: author).

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1.3 Australian industry representation

Prior to 2024, there was no specific industry body for the Australian native finger lime sector. Finger limes were either considered to belong to Citrus Australia, Australian Native Foods and Botanicals (ANFAB) or Hort Innovation Australia (HIA), with grower membership occurring across these representing bodies. Across all of these industry bodies, finger limes were not significantly acknowledged nor considered for commercial production.

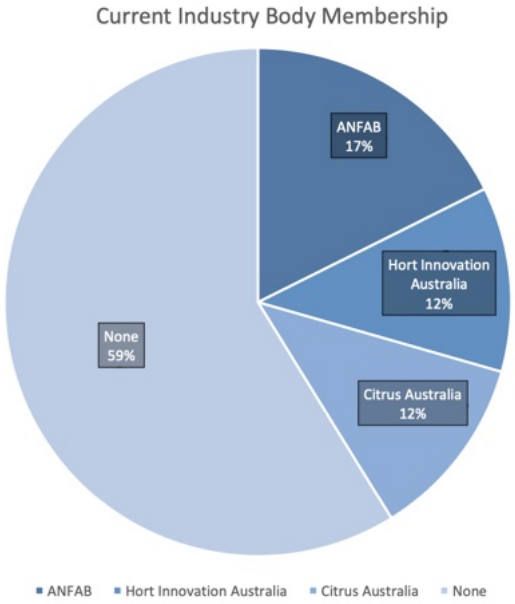

Figure 11. Industry Body Membership adoption amongst finger lime producers, (AgriFutures Australia, 2021).

1.3.1 Australian Native Foods and Botanicals (ANFAB)

ANFAB (previously operating as ANFIL - Australia Native Food Industry Limited) is the peak industry body representing the interests of people and businesses involved in the native food and botanicals industry. ANFAB represents 13 different native foods and botanicals and has a webpage dedicated to finger lime production. Whilst 17% of finger lime producers have been a part of this industry body, the representation as a commercial crop is limited to a single webpage.

1.3.2 Citrus Australia

Citrus Australia has over 300 grower and affiliate members, and provides grower representation in the areas of labour, water, biosecurity, market access, agrichemicals, infrastructure, energy, research and development (Citrus Australia, 2024). Citrus Australia represents the Australian production of oranges, mandarin, tangelo, lemon, lime, grapefruit and pomelo. Whilst grapefruit and pomelo make up only 1% (131 hectares) of the national hectares of citrus represented, the national hectares of finger limes are expected to be larger than grapefruit and pomelo combined. Despite this, finger limes are not represented under Citrus Australia, and the CEO has indicated to the author that it would not be well represented under that industry body (Nathan Hancock, pers. comm., 2022).

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1.3.3 Hort Innovation Australia (HIA)

HIA represents 37 different levied industries and conducts strategic investments in research and development, and marketing programs, specific to the industry needs and priorities. The citrus industry is levied, and numerous research projects are being undertaken, however, none to date have addressed the development of commercial finger lime production. While 12% of finger lime growers are members with HIA, without representation and levy recognition, there are no benefits directed specifically to the finger lime industry.

1.3.4 Australian Native Fingerlime Alliance (ANFA)

AgriFutures Australia identified that it was a very high priority to establish an independent industry body, or a subcommittee within the existing industry body Australian Native Food and Botanicals, to represent the finger lime industry, in its report titled, *Research, Development and Extension Plan for the Australian Native finger lime Industry, 2021–2026*.

finger lime producers also acknowledged the need to unite growers across the value chain and drive progress, and in early 2024 the Australian Native Fingerlime Alliance (ANFA) was established. ANFA states it “aims to lead the world in the production and knowledge of Australian finger limes and promote and foster pro-active management for commercial finger lime growers” (ANFA, 2024). Subsequently, ANFA seeks to embrace a responsible leadership role in the future of the Australian finger lime industry. ANFA currently has over 34 grower members across all eastern states of Australia that account for over 50 000 trees.

ANFA has already directed research and increased representation within Australia, and addressed other key issues identified by AgriFutures Australia, such as running workshops for industry stakeholders to enhance the capabilities of producers in the industry.

Figure 12. The Australian Native Fingerlime Alliance logo, (source: ANFA, 2024).

1.4 International industry representation

The commercial production of Australian native finger lime (*Citrus australasica*) as an emerging industry in need of provenance, research and representation.

Outside of Australia, there are no industry bodies specifically representing finger lime in the world. Similar to Australia, the commercial development of a finger lime industry is in its infancy, and are usually lumped in with citrus industry bodies, however unlike Australia, they are not also spread across different industries such as natives for obvious reasons.

Figure 13. Map of current known growing locations of finger limes across the world, (source: author).

International travel research found that whilst the benefit of producers only having the one representative body ensured more accurate accounting of finger lime production, it was also found that due to the low percentage in comparison to major citrus within that body, all representation of the fruit was predominantly for the benefit of the major groups and not to finger limes itself (University of California, pers. comms., 2023). For example, in California, the primary research undertaken using Australian finger lime is for the benefit of the major citrus varieties, where they are using finger lime to provide pathogen resistance-related genes that can be used to add HLB tolerance into conventional citrus cultivars (Webster, et al., 2022).

Figure 14. University of California – UC Riverside Citrus Research Centre, (source: author).

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Chapter 2: Finger lime agronomic practices

The first commercial production of finger limes in Australia began in the 1990s, transitioning from wild harvesting to structured farming. In the wild they are in competition for light and nutrients, and as such have a lanky habit and have very little fruit production (Figure 15). This transition to cultivation saw a significant increase in fruit production per tree and a more dense habit result. Producers over time developed agronomic practices through trials and experiences, however, very little replicated research has been devoted to finger lime production. In fact, AgriFutures Australia identified the development of an Australian finger lime best practice manual as a high priority in the *Australian Native finger lime RD&E Plan (2023-2028)*.

Figure 15. Finger lime growing naturally in Springbrook National Park, (source: author).

2.1 Geographical location

Finger limes are native to the subtropical rainforests of Queensland and New South Wales, Australia. Their endemic habitat provides well-drained, slightly acidic soils and a warm, frost-free climate.

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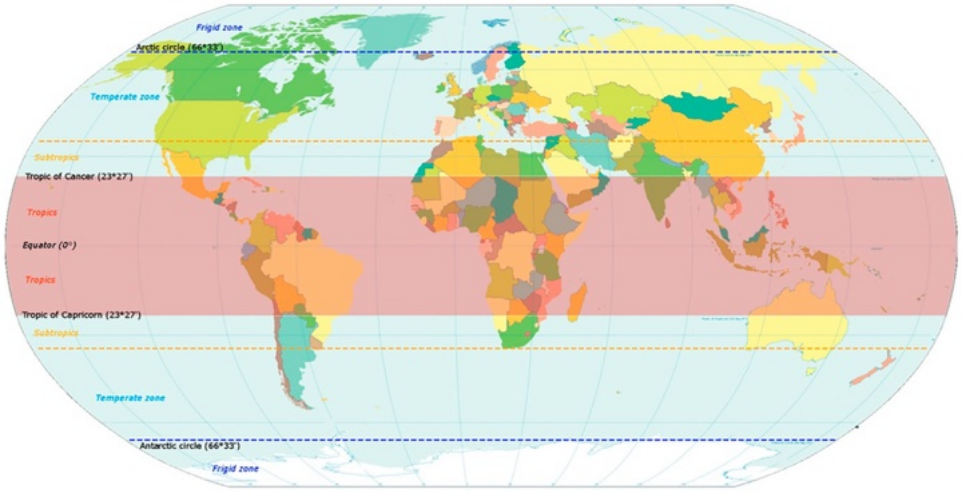

Figure 16. Map of the world indicating the tropical and subtropical zones, (source: Mavridou, et al., 2018).

2.1.1 Australia

Despite the finger lime endemic geographical location being in the subtropics of south east Queensland and northern New South Wales, commercial production outside of these regions has been successful. In Australia alone, finger limes are grown successfully from far north tropical Queensland down to Victoria's mild-temperate region.

Temperature has been noted as one of the influences for Australian producers, with colder regions having a much shorter harvest window. Sub-tropical producers harvest fruit from December through to July, whilst in mild-temperate regions, harvest is recorded to be from February through to May. Despite the window differences, the volume of production remains similar per tree, but ultimately the volume of production per tree is significantly related to the varieties.

Table 3. Pros and cons to the different harvest window lengths.

	Long Harvest	Short Harvest
Markets	Ideal for fresh fruit market	Ideal for processing
Timing	Early and late prices	Ready at peak time
Financial	Extended income	Lump sum unless processed

In Australia, some nurseries are working towards developing trees more adapted to colder climates and have had success in this regard.

Warmer, wet climates like tropical Queensland have resulted in fungal disease issues, particularly with root rot pathogens and branch dieback. This has also been an issue in subtropical regions that have experienced long periods of wet weather.

Dryer regions consistently raise concerns about the need to maintain consistent watering, with trees suffering significantly if the soil is allowed to dry out, especially during hot periods.

2.1.2 Internationally

On a global scale, some finger lime production aligns with the more prominent citrus growing areas, such as the San Joaquin Valley in California. However, some large scale citrus growers that established orchards of up to 2500 trees around Visalia found it unproductive due to the colder weather and removed all trees (Doug Phillips, pers. comms., 2023). Shanley Farms at Morro Bay, and Goodland Organics at Santa Barbara, which are closer to the coast and have a milder climate, are continuing to have success.

Contrary to this many orchards are established in alternate areas more reflective of the endemic subtropical area that the finger lime originated from, such as Guatemala. It is in these areas that producers are promoting year-round supply of fresh fruit, which can be directly attributed to the climatic conditions.

Morocco's season is also short and is known to many Northern Hemisphere growers to flood the market with finger limes all at once during this time.

2.2 Orchard design

2.2.1 Soil types

Finger limes are grown across various soil types with a range of pH, however it has commonly agreed that a well-drained soil with a pH of between 5 and 6.5 is ideal for production. In areas where heavier soil types are present, it is recommended to hill the soils up to enable adequate drainage. Prolonged moisture around the tree roots causes disease in the trees.

2.2.2 Spacing and densities

Primary spacing across orchards has been 2.5 – 3 metres between trees and 4 – 5 metres between rows, which equates to 600 to 800 trees per hectare (DAF, 2010). A producer has noted growing at higher density planting at 1.8 metres between trees and 2.5 metres between rows, and had success to date indicating this is a possibility. However, finger lime tree habit varies significantly across varieties, from tall upright trees with open canopy to smaller dense shrubs with a weeping habit, which subsequently alters the tree spacing requirements.

The commercial production of Australian native finger lime (*Citrus australasica*) as an emerging industry in need of provenance, research and representation.

2.2.3 Aspect

Despite originating in the rainforest, highly productive commercial finger lime orchards do best in full sun. To maximise light interception and subsequently greater flowering and reduced disease, commercial plantings implement a hedgerow system and plant trees in rows that run north-south. However, due to the proliferation of flowers on finger limes, aspect is suspected not to significantly affect flowering.

Figure 17. Young 2 year old orchard at Green Valley Fingerlimes, (source: author).

2.3 Nutrition

There have been no specific research trials conducted on finger lime tree nutrient requirements to date, and it has been assumed they need less fertiliser than other commercial citrus varieties in the past. Current nutrient management techniques are based on grower knowledge and experience, and very little is advised by experienced agronomists. As good practice, it is generally recommended that soil and leaf tests be conducted each year, prior to flowering, to gauge the nutrient requirements for the coming season and any significant issues in uptake.

2.3.1 Macronutrients

Due to a lack of research, producers follow various nutrient management plans primarily adopted for other crops. Many current finger lime producers have indicated that they follow a similar NPK fertiliser regime as commercial citrus operations. Alternatively, as finger lime trees in commercial orchards have a more fibrous root system with the majority of feeder roots usually in the top 30–60 centimetres of soil similar to macadamias, another native, some producers follow a nutrient program used by this industry. Whilst the programs followed are varied, it is common for producers to apply a complete NPK fertiliser 3-4 times a year.

The commercial production of Australian native finger lime (*Citrus australasica*) as an emerging industry in need of provenance, research and representation.

2.3.2 Micronutrients

Micronutrients are often applied by foliar or fertigation techniques to adjust deficiencies in both the leaf and soil. Common issues noted are zinc deficiency, which plays a role in disease defence and reproduction, and boron which is vital for flower production and subsequent reproduction. If the orchard is treated to reduce fungal issues, copper is usually not deficient.

2.3.3 Amendments - Kelp

Many growers advocate the use of kelp products, in particular for overall plant health. They apply this as both a soil and foliar application. To date, no research has been conducted to ascertain if finger lime absorb nutrients through their leaves.

2.4 Water

2.4.1 Moisture level

Ideally, the orchard soil moisture should not drop below 5% for an extended period of time. Once finger lime trees show signs of water stress, it is very difficult to remedy. Ideally, the soil profile should never completely dry out for over a week. In hot dry areas it is recommended to ensure the trees are well mulched. Conversely, the soil profile should not remain saturated for too long as it promotes root rot and disease. Soil moisture monitoring equipment such as tensiometers should be installed in the orchard to help schedule irrigation correctly so as not to under or over-water trees.

2.4.2 Irrigation

Water is essential throughout the year, however, it is especially important at flowering and fruit set and into the growth period for quality fruit production. Whilst water quantities will vary depending on soil type, seasonal conditions and age of plant, it should be considered that at least 20 litres per plant may be required per week, which for an 800 tree/ha spaced orchard equates to 16 000 litres per week per hectare.

Drip or sprinkler irrigation is recommended with each having pros and cons. If limited by water and pump pressure, drip irrigation is more effective. All irrigation water needs to be checked for pH and salinity periodically.

2.5 Pruning

Trees respond well to regular light pruning to open the canopy up to increase air circulation and increase light penetration. It is recommended that the lower branches be skirted to enable air circulation and reduce disease, keep fruit off the ground and enable better weed management

under the trees. Any rootstock sucker must be removed. Pruning is best done after harvest to enable the tree to recover before flowering.

Figure 18. Demonstrating pruning techniques in Guatemala at Prime Tropics, (source: author).

The commercial production of Australian native finger lime (*Citrus australasica*) as an emerging industry in need of provenance, research and representation.

Chapter 3: Varietal classification and standards

There is an enormous diversity of native finger lime varieties, with currently over 30 varieties stocked in nurseries and grown by producers in Australia. Furthermore, significant development of varieties internationally is occurring at Lakeside California University and the University of Florida. In addition, fruit specifications with set standards are not available for any of the varieties, leaving significant variation between producers worldwide.

3.1 Varietal classification

Currently in Australia, the finger lime fruit, or citrus caviar, is becoming well known, with the arthur noting that over 80% of consumers generally know what they are, however, no additional knowledge of the different varieties has been established. There are over 30 finger lime varieties stocked in nurseries, and well over 40 known in the wild, though not all these varieties produce marketable fruit (AgriFutures Australia, 2022). AgriFutures Australia (2022) identified that use of different names for varieties caused confusion among consumers and an industry led standard for naming of varieties and cultivars needs to be established.

Worldwide, the finger lime fruit is still not commonly known, with it being more on the lines of 20% commonly knowing what finger limes are. This has even been the case with producers with many not knowing what variety they have. Even some producers believe they are growing finger lime, which is in fact Frustrime, an F1 hybrid of *Citrus australasica* x lime. In Italy this is an issue as consumer confidence is lost when the expected round caviar pearls are not found inside the Frustrime, instead a more commercial-like oval citrus vesicles exists.

3.2 Fruit specifications and standards

Finger lime standards are essential for ensuring consistency in quality and meeting market demands. Variety standards are determined based on attributes such as optimal size, shape, skin colour, vesicle colour and flavour. These classifications help differentiate finger limes for both domestic and international markets, enhancing their commercial appeal.

Key standards possible for finger limes include:

1. **Size**: Finger limes typically range from 4 to 12 centimetres in length.
2. **Shape**: Finger limes have an elongated, finger-like shape, which gives them their name.
3. **Skin Colour**: Finger lime varieties exhibit a range of skin colours, from green and yellow to pink, red, black and dark purple.
4. **Vesicle Colour**: The internal juice vesicles of a finger lime, or "citrus caviar," vary in colour, including green, pink, yellow, and red.

The commercial production of Australian native finger lime (*Citrus australasica*) as an emerging industry in need of provenance, research and representation.

5. **Flavour**: Flavour profiles of finger limes range from tangy and citrusy to mildly sour, depending on the variety.

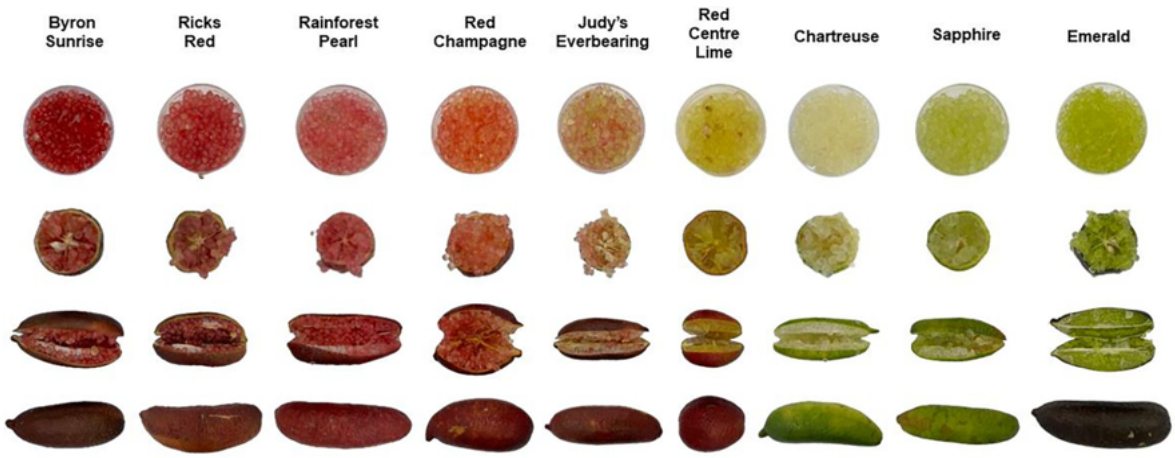

Figure 19. Range of colours and shapes of just a few of the finger lime varieties, (Nastasi, et al., 2024).

To date there are no set industry standards for any of the varieties, however, these are crucial for growers and retailers to ensure finger limes meet the expectations of consumers and culinary professionals. Establishing uniform varietal standards also supports marketing efforts and boosts consumer confidence, helping the finger lime industry maintain its reputation for high-quality produce. Furthermore, fruit specifications need to be standardised to reduce market confusion and ensure a consistent quality standard (see Appendix 1).

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Chapter 4: Provenance and Intellectual Property

The main types of Intellectual Property Rights include patents, trademarks, copyrights, trade secrets, industrial designs, geographical indications, and plant variety rights.

4.1 Provenance and cultural significance

Provenance highlights the origin and history of food products, emphasising authenticity and traceability. A key example is Parma ham (Prosciutto di Parma) from Italy, which holds a Protected Designation of Origin (PDO) status, ensuring it's produced only in specific regions of Parma using traditional methods. Another example is Champagne, which can only be labelled as such if it comes from the Champagne region of France, following strict production standards. In Australia, Kangaroo Island honey is valued for its pristine environment and unique Ligurian bees, promoting its provenance. These examples enhance consumer trust, marketability, and premium pricing for the products.

Culturally significant food products are deeply tied to the traditions and heritage of a region or community. Examples include sushi from Japan, a culinary art form symbolising simplicity and precision, and Kimichi in Korea embodies centuries of fermentation techniques and cultural identity. These foods not only reflect cultural identity but also promote culinary heritage and history worldwide.

Both provenance and cultural significance are instrumental to Australia's success globally in the finger lime industry. AgriFutures Australia (2022) identified the need to develop provenance for Australian-produced fruit to differentiate from the world and subsequently increase value, and enable the industry to compete on a global scale. Furthermore, finger limes as an Indigenous Australian bushfood are significant for their connection to Aboriginal culture and traditional knowledge. This respect for provenance and cultural significance, combined with sustainable cultivation practices, promotes ethical industry growth and positions finger limes as a premium, product in the global food market.

Recognising the Indigenous origins and protecting intellectual property (IP) also demonstrates acknowledgement and respect for culture. An interesting example of recognition and ties to Indigenous use is the Pecan industry. Many pecan varieties are named after Native American names like Cheyenne, Sioux, Choctaw, Kiowa and Creek, as they were an extremely significant part of pre-colonial Coahuiltecan diets. To date, all finger lime variety naming has been based on colour and/or location, however, some use of the Indigenous name, Gulalung, from Bundjalung country in the Northern Rivers of New South Wales, has been used infrequently.

The commercial production of Australian native finger lime (*Citrus australasica*) as an emerging industry in need of provenance, research and representation.

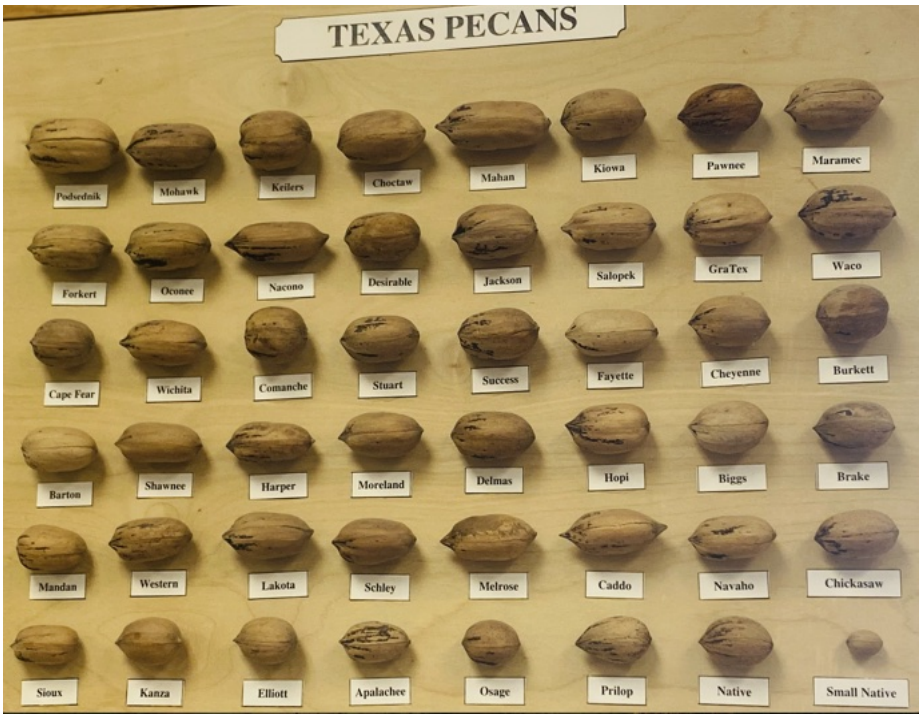

Figure 20. Texan pecan varieties with many Native America names, (source: author).

4.2 Intellectual Property

In Australia, the intellectual property laws relevant to the protection of plants and plant-based traditional knowledge are copyright, patents, plant breeder's rights, confidential information, trademarks and geographical indications (Janke, 2018).

Though plant breeder's rights (PBR), trademarks and patents play a role in IP protection, there is no protection for the native finger lime varieties that have been lost to other countries, which as has been noted, has already occurred. However, there is an increasing push for the Australian Government to prevent the loss of Australia's native food resources and consider how recognition of a provenance be addressed. The Nagoya Protocol could then be applied to native bush food.

The Nagoya Protocol is an international agreement under the Convention on Biological Diversity that regulates access to genetic resources and the fair sharing of benefits arising from their use. For Australian Indigenous foods, the protocol emphasises respecting and safeguarding Indigenous rights and knowledge, particularly concerning native plants like finger limes and Kakadu plums. This includes securing consent from Indigenous communities when their resources or traditional knowledge are utilised for commercial purposes.

The commercial production of Australian native finger lime (*Citrus australasica*) as an emerging industry in need of provenance, research and representation.

4.2.1 Plant Breeder's Rights

Plant breeder's rights (PBR) describes the type of intellectual property that protects new varieties of plants and trees (Queensland Government, 2024). To date, only one finger lime cultivar has PBR classification applied, being *Citrus australasica var sanguinea* 'Rainforest Pearl' which is a pink-fruited cultivar applied for by Byron Bay Native Produce, Bangalow, New South Wales (APB, 2024).

4.2.2 Trademark

A trade mark is a type of intellectual property (IP) right that distinguishes your unique brand, product or service from other competitors in the market (IP Australia, 2024). To date, there are no trademarks that include the Australian native finger lime (APB, 2024).

4.2.3 Australian Cultivar Registration Authority (ACRA).

Australian Cultivar Registration Authority (ACRA) is the "International Registration Authority for Australian plant genera excluding those covered by other authorities" according to the International Code for Nomenclature of Cultivated Plants. This includes all endemic genera and all predominantly Australian genera.

There are seven registered finger lime cultivars on the Australian Cultivars registration list (ACRA, 2024), as noted below;

- Citrus australasica' Alstonville',
- Citrus australasica' Blunobia Pink Crystal',
- Citrus australasica' Durhams Emerald,
- Citrus australasica' Judy's Everbearing' and
- Citrus australasica' Pink Ice'.
- Citrus australasica 'Jali Red'
- Citrus australasica 'Byron Sunrise

4.2.3 Indigenous Cultural and Intellectual Property

Indigenous Cultural and Intellectual Property (generally known as ICIP) refers to the rights that Indigenous people have, or want to have, to protect their traditional knowledge and culture. This was heavily featured in 2023 at the National Sovereign Food & Botanicals Symposium in the Northern Territory. Whilst finger limes were discussed, it primarily addressed the protection and acknowledgement of cultural knowledge surrounding medicinal uses and benefits long known and practised by the Indigenous tribes.

The commercial production of Australian native finger lime (*Citrus australasica*) as an emerging industry in need of provenance, research and representation.

4.2.4 Geographical Indication

A geographical indication (GI) is a name or sign used on products to indicate the particular place the product comes from. A GI is an intellectual property tool used to identify that a product has certain qualities or a reputation, due to its geographic origin. The GI protects the name by preventing the generic uses of the name and preserving it for use on products made in the traditional manner.

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Chapter 5: Market opportunities

Finger limes offer significant market opportunities in Australia, driven by increasing consumer interest in native and gourmet foods. Their unique appearance, often referred to as "citrus caviar," and diverse flavours make them highly sought after by chefs and restaurants, both domestically and internationally.

5.1 Market summary of Australia

Finger limes have an incredibly diverse range of market opportunities from fresh to the growing potential for value adding to products. The fresh finger lime market in Australia currently dominates the majority of supply, with much of this being sold in wholesale markets nationally and where possible, internationally. Fresh finger lime is predominantly supplied the food services industries, however more fruit is starting to make its way into retail chains. Due to an increase in producers and subsequent supply in peak times, it is imperative for finger limes to become a commonality in the major supermarket chains. It is envisaged that finger lime will soon be on the shelves of major retail stores beside blueberries, strawberries and the like. However, this will only be possible with consistency in product, hence variety, to ensure consumer confidence in the fruit.

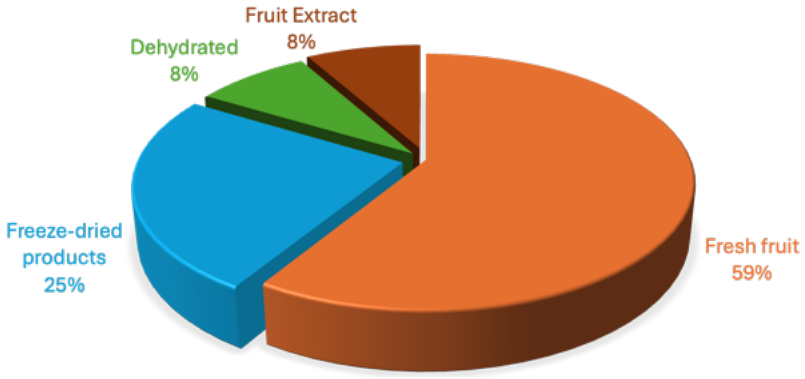

Figure 21. Market percentages for finger limes in Australia.,source: AgriFutures Australia, 2022).

The second largest market sector is freeze-dry products. This is predominantly for powders as flavour additives and has seen a lot of excess fruit utilised. As supply outstrips demand during peak seasons, more producers are looking to freeze-drying to extend the shelf life and increase revenue. Powders can be used to add flavour to beverages, yogurt and many more consumables.

Whilst this is a growing market, it can be argued that the true uniqueness of finger limes is the citrus caviar pearls, however, current studies indicate that finger lime also provides unique nutritional benefits. Nutritional research has found finger limes to have high levels of ascorbic acid and moderate to low levels of total phenolics and antioxidant capacity, and high levels of

tocopherols (Delort and Jaquier, 2009; Johnson, et al., 2021; Konczak, et al., 2010; Netzel, et al., 2007).

As the powdered product enables use throughout the year, the addition of a high-end and expensive Australian bushfood flavour to be added to various products, the issue of possible adulteration of the product with cheaper alternatives has been highlighted. Nastasi, et al., (2024) research found the possibility for rapid monitoring protocol of the product is possible to guarantee the authenticity of natural products (Figure 22).

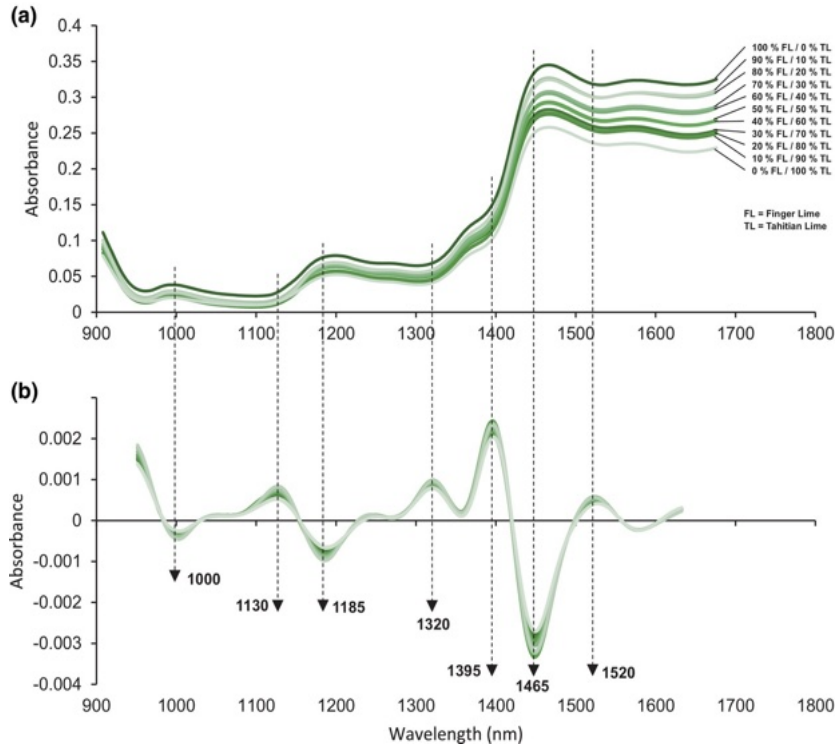

Figure 22. Near-infrared (NIR) raw (a) and second-derivative spectra (b) of commercial finger lime powder adulterated with Tahitian lime powder collected using a portable NIR instrument, (source: Nastasi, et al., 2024).

Fruit extracts are a growing sector of the industry with finger lime now being used for pharmaceuticals and cosmetics. Finger lime extracts are valuable for skincare products due to their antioxidant properties, offering potential in beauty and personal care markets.

5.2 Global markets

5.2.1 Export from Australia

Finger lime exports from Australia are limited by MICOR (Manual of Importing Country Requirements) standards that place restrictions on the export of certain fruit to different countries. The Department of Agriculture, Fisheries and Forestry controls exports of agricultural products

and assures agricultural products meet MICOR import requirements. For example, the European Union MICOR requirements state that the finger lime fruit must be free from pests, soil, weed seeds and extraneous material, have a phytosanitary certificate, Black spot (*Phyllosticta citricarpa*) inspection certificate declaring freedom of the disease, and must be cold stored at 3 degrees Celsius, or below, for 16 days to exclude fruit fly (MICOR, 2024).

Due to the cold store requirements, significant studies have been conducted to determine the optimal cold store temperature to maintain the structural integrity of pearls of different finger lime varieties. Nastasi, et al., (2024) researched the physical properties of finger lime pearls, especially their diameter, colour, and mechanical properties, to gain an understanding of how these attributes can be used for quality assessment, consumer preference, and marketability in the food industry (Figure 23).

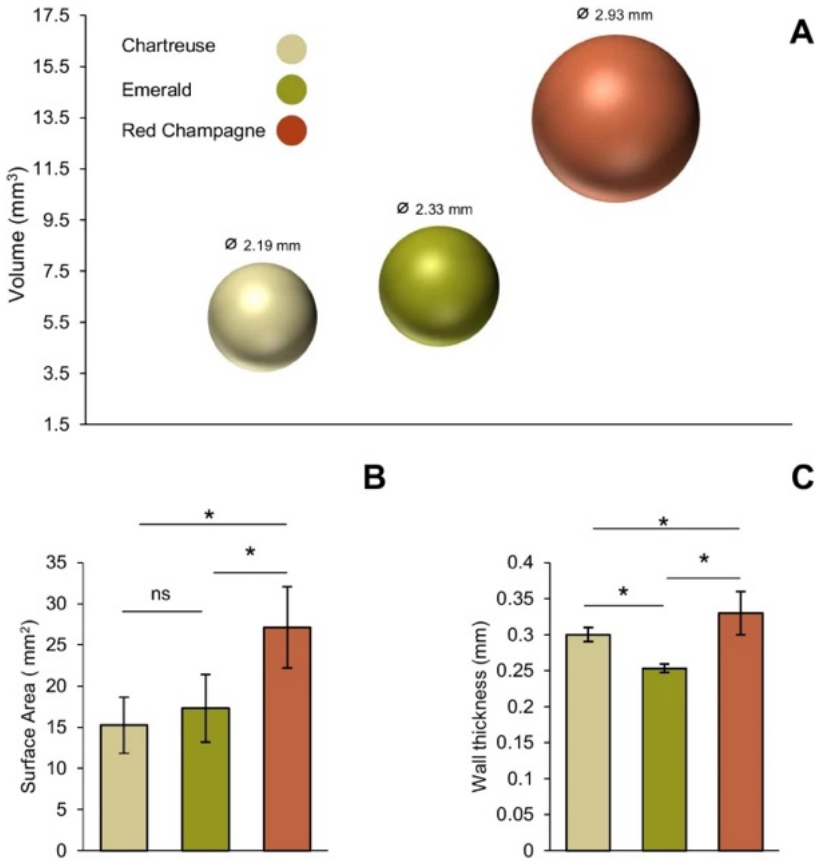

Figure 23. Volume (A), surface area (B), and wall thickness (C) of 'Red Champagne', 'Emerald', and 'Chartreuse' finger lime pearls, (source: Nastasi, et al., 2024).

Further research was conducted to explore the use of portable infrared spectroscopy as a quality assurance tool for the Australian native and traditional food industry with a case study on finger lime (*Citrus australasica*) (Nastasi, et al., 2024). During this study it was found that the Red Champagne variety maintains the greatest condition at 4 degrees Celsius.

The commercial production of Australian native finger lime (*Citrus australasica*) as an emerging industry in need of provenance, research and representation.

5.2.2 International markets

Internationally, predominantly in the Northern Hemisphere, some of the biggest exporters are the USA, Guatemala and Morocco, with most of the exports heading to the European Union. Whilst not under the same MICOR requirements of storage prior to export, research has already been conducted to assist with shelf life by Florida University, titled *Postharvest Changes That Occur in finger limes at Chilling and Non-Chilling Temperatures*.

Across all finger lime producing countries, similar market avenues have been established, from fresh through to pharmaceutical oils.

Along with the MICOR standards, geographical location limits Australia's capability to be as competitive with international fresh finger lime production. However, due to seasonality windows, as with most fresh produce, Australia can be competitive at various times.

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Conclusion

The Australian native finger lime is a unique fruit with significant commercial potential and its endemic and cultural provenance to Australia emphatically supports the notion that Australia be the leader of the world in this industry. This can only happen by uniting the producers and affiliates under a dedicated industry body. This then will enable unified advocacy, market development, increased research and development of best management practices. It is encouraging to see that since the establishment of Australian Native Fingerlime Alliance (ANFA), these objectives are being addressed and even more encouraging that they are being heard.

Ultimately it is now a priority for ANFA to establish agronomic guidelines and unite growers to produce the best product under best-practice, sustainable management. ANFA engaging in grower workshops and working with research institutions along these pathways is ideal, however significant government assistance is required.

Furthermore, it can be concluded that a greater understanding of specific finger lime varieties is essential for both research and market development, as it allows for the identification of the most commercially viable options. Narrowing the focus to these and other high-performing varieties will help growers maximise profitability, reduce variability, and streamline supply chains. It will also enable more targeted research on disease resistance, yield optimisation, and climate adaptability, further strengthening the commercial success of the finger lime industry.

Once optimal commercial varieties are identified and streamlined, it is imperative for the industry to create market understanding and demand globally to prevent limited opportunities and encourage future investment. Differentiating Australia’s finger lime from the world through advocacy of provenance and cultural identity is a way to enable Australia to compete on a global scale.

The commercial production of Australian native finger lime (*Citrus australasica*) as an emerging industry in need of provenance, research and representation.

Recommendations

- Increase ANFA membership to have power in numbers.
- ANFA to consider becoming a levied industry to garner financial assistance for much needed research and market development
- Establish a grower's guide with associated agronomic research and sustainable management practices to ensure Australian producers have the capacity to lead the world in quality and production.
- Market provenance and secure IP
- Refine and define the most suitable commercially viable finger lime varieties
- Establish market guidelines and specifications to ensure consistency for the consumer
- Develop a gene bank of finger lime trees to secure genetics for the future
- Expand international market access

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Appendix 1: Green Valley Fingerlimes Produce Specifications

PRODUCE SPECIFICATIONS

PRODUCE:	**CITRUS**

TYPE	finger lime	**VARIETY**	Champagne Red
CLASS	First	**NOTES**	

GENERAL APPEARANCE CRITERIA	
Colour	Dark maroon to red skin, nil with very dark green skin. Pale yellow through to a deep red flesh.
Visual Appearance	Smooth, waxed surface; rind < 2mm thick; no foreign matter. Pre-packs labelled with bar code. Loose Fruit stickered and variety name per requirements.
Sensory	With firm, smooth skin, small oil glands; strong, tangy aroma and flavour, no foreign odours/tastes.
Shape	Long cylindrical shaped fruit.
Size	As per pre-ordered size requirements, minimum net carton weight 2 kg., generally large fruits, max 20% variation within lot.
Maturity	Citrus pearls erupt, Brix 11-13.
MAJOR DEFECTS	
Insects	With insects (eg. mealy bugs), especially in navel or button, or >10 scales (red/brown spots).
Diseases	With fungal or bacterial rots of the skin or flesh (eg. Penicillium moulds, brown rot, soft rots). With dark lesions on the fruit skin (eg. Black spot, Septoria spot). With raised, corky areas on the fruit skin (scab).
Physical/Pest Damage	With cuts holes, splits, and cracks (that break the skin).
Temperature Injury	With dark brown depressed lesions (chilling injury) or watersoaked flesh (freezing damage). With pale, hard areas of skin (severe sunburn)
MINOR DEFECTS	
Diseases	With superficial black/grey marks (eg.sooty blotch, sooty mould, Melanose) affecting in aggregate >1sq cm.
Physical/Pest Damage	With brown/black specks (rust mite damage) affecting in aggregate > 1sq cm. With up to 10 scale insects (red-brown spots, 2mm diameter). With slightly dark and sunken areas (oleocellosis) affecting >1 sq cm. of surface.
Phycological Disorder	With sunken pits in the fruit rind (Peteca).
Skin Marks/Blemishes	With dark blemishes (eg stem end blemish) affecting in aggregate > 1 sq cm. of surface. With light blemish affecting in aggregate > 3 sq cm. of surface.
Temperature Injury	With bleached yellowish-orange areas (slight sunburn) affecting > 3 sq cm.
CONSIGNMENT CRITERIA	
Tolerance Per Consignment	Total minor defects (within allowance limit) to be < 2 defects per item Total minor defects (outside allowance limit) must not exceed 10% of consignment. Total major defects must not exceed 2 % of consignment.
Packaging and Labelling	Packaging manufactured from new food grade materials. All labelling must meet the current legislative requirements. Labelling to identify grower's name/brand (plus growers name, address, contents, class, size and/or minimum net weight. Produce to identify Country of Origin (eg. Produce of Australia) on outer container.
Shelf Life	Produce must provide not less than 14 days clear shelf life from date of receival.

The commercial production of Australian native finger lime (*Citrus australasica*) as an emerging industry in need of provenance, research and representation.

Receival Conditions	Compliance with Quarantine Treatments (if required) for Interstate Consignment. Temperature 5 - 10°C for Receival.
Chemical & containment Residues	All chemicals used pre/postharvest must be registered and approved for use in accordance with the requirements of the APVMA regulatory system. Residues, Contaminants and Heavy Metals to comply to the FSANZ Food Standards Code ML's and MRL's.
Food Safety Requirements	Produce is to be grown and packed under a food safety program that is subject to an annual third- party audit. A copy of current certification to be forwarded to receiver.